Negation and distributivity in event semantics

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1 Introduction

- In event semantics (Davidson 1967), two main options are available for the semantic interpretation of verbs:

  1. as sets of events (e.g. $[\![\text{run}]\!] = \lambda e.\ \mathit{run}(e)$) (Parsons 1990);
  2. as quantifiers over events (e.g. $[\![\text{run}]\!] = \lambda f.\ \exists e.\ \mathit{run}(e) \wedge f(e)$ — compare to $[\![\text{a kid}]\!] = \lambda P.\ \exists x.\ \mathit{kid}(x) \wedge P(x)$) (Champollion 2015)

- Option 1 integrates well with mereological approaches and is at the core of (Champollion 2016a,b) treatment of distributivity that successfully analyses sentences such as (1):

  (1) a. The kids each saw two monkeys.
  b. The kids wore a black hat.

- However, option 1 leads to some difficulties when quantification (*John kissed every girl*) or negation (*John didn't laugh*) is involved (Winter & Zwarts 2011, de Groote & Winter 2015). Less so for option 2 (Champollion 2015).

- Negation is problematic for mereological treatments of distributivity (Schwarzschild 2014).

  (2) Three kids each did not eat an egg.
  (meaning *There are three kids none of which ate any egg.*)

- The standard analysis of negation in event semantics: *it is not raining* translated as $\neg\exists e.\ \mathit{rain}(e)$.

- This analysis of negation conflicts with the distributive view, for which the intuition is instead to sum "non-eating an egg" events for each of the kids.

Today's goal: We are looking for an account of negation that is compatible with the mereological view of distributivity and that also sticks to the traditional view of verbs as sets of events.

(3) Attested examples:

a. File this in lieu of a full report *only if* aggregate receipts, expenditures, or liabilities incurred *each* did not exceed $250.00 during the reporting period.

b. The two lists referring to positive qualities serve as a reminder of several good qualities you each have and show that you each don't believe the other to be a bad person.

c. In addition to Sarah, Alexis Waters was also eliminated at the second Rose Ceremony because they each didn't find a match in Paradise.

d. The 2 cachers who logged DNFs simplify state that they each didn't find the cache (for whatever reason, that is).

e. Yes, Ohio State and Indiana were our best or among our best when the Challenge started, and they each didn't participate multiple years.

f. The size equality between the Roy and the Vib was the main reason they each didn't try to take the Well from The Multi Facet in the first place.

g. These shows were very different, but, like most musicals, they each didn't make money here.

2 Champollion's (2016b) account of distributivity

- All thematic relations and all verbs (but not other verbal projections) are closed under mereological sum.
- All verbs and verbal projections denote sets of events.
- ${}^*\lambda e'.\ P(e')$ denotes the set of all sums of one or more $e' \in P$.

(4) $\exists e.\ e \in {}^*\lambda e'.\ P(e')$
There exists an event (e) that consists of one or more subevents (e'), each of which is a P event.

- Adverbial *each*:

(5) $[\![each_\theta]\!]^{adv} \equiv D_\theta \equiv \lambda V e.\ e \in {}^*\lambda e'.\ [atom(\theta(e')) \wedge V(e')]$

(6) The boys { $D_{\mathtt{Ag}}$ / each } ate a cookie.
$\exists e.\ \mathtt{Ag}(e) = \bigoplus boy \wedge e \in {}^*\lambda e'.\ [atom(\mathtt{Ag}(e')) \wedge eat(e') \wedge cookie(\mathtt{Th}(e'))]$
There is an event whose agent (Ag) is the boys, and which consists of one or more subevents each of which is an eating event whose agent is an atom and whose theme (Th) is a cookie.

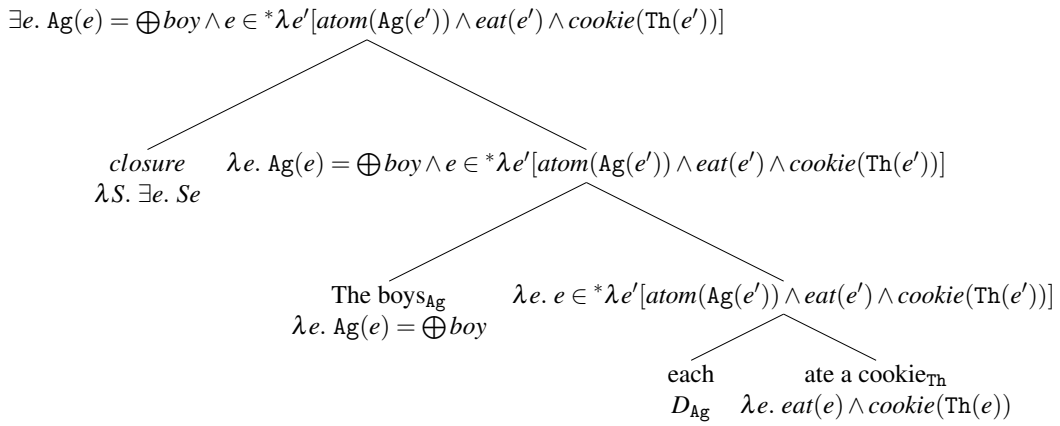

Figure 1: Champollion's (2016b) derivation for "The boys each ate a cookie."

3 Negative events?

- In (7), *not* does not seem to function as simple negation (Higginbotham 1983).

  (7) Hagen watched his plants not grow.
  - a. $\neq$ Hagen did not watch his plants grow.
  - b. $\neq$ Hagen watched his plants doing something else than growing.
  - c. $\neq$ Hagen watched something that was not his plants growing.
  - d. $\approx$ Hagen watched the non-growing of his plants.

- Idem in (8):

  (8)
  - a. I kept the kids awake by not turning out the light.
  - b. For two hours, Mary did not laugh.
  - c. John and Mary each did not build a raft.

- Higginbotham (1983, 2000) considers negative events, but with an incomplete logic and without a syntax-semantics interface.

- As long-term goals, we would like:
  - a notion of negative events with a proper logic;
  - a precise syntax-semantics interface to account for examples (7) and (8) in event semantics.

4 Actuality of events and negation

- We suppose that events can either be actual or non-actual.

- $actual(e)$ can be taken to mean that e is in the actual world ($[\![actual(e)]\!]_{M,w} = e \in w$).

- We will assume one first axiom, related to mereology:

(9) $\forall e.\ actual(e) \leftrightarrow (\forall e' \sqsubseteq e.\ actual(e'))$

- $Neg : (v \to t) \to v$ is a function that sends a set of events P to an event $Neg(P)$, the *canonical precluder* of P, obeying the following axiom:

(10) **Axiom of negation**
$actual(Neg(P)) \leftrightarrow \forall e \in P.\ \neg actual(e)$

(11) a. It is raining.
b. $\exists e.\ actual(e) \wedge rain(e)$

(12) a. It is not raining.
b. $actual(Neg(\lambda e.\ rain(e)))$

5 Logical properties

5.1 Double negation

One wants (13a) and (13b) to be logically equivalent.

(13) a. Mary did not not eat an egg.
b. Mary ate an egg.

Let P be any event predicate. Then:

$$\begin{aligned} actual(Neg(\lambda e.\ e = Neg(\lambda e'.\ P(e')))) &\Leftrightarrow \forall e.\ e = Neg(\lambda e'.\ P(e')) \to \neg actual(e) \\ &\Leftrightarrow \neg actual(Neg(\lambda e'.\ P(e'))) \\ &\Leftrightarrow \exists e'.\ P(e') \wedge actual(e') \end{aligned} \quad (1)$$

5.2 Downward entailment

Downward entailment is illustrated by logical entailments of the form (14a) $\Rightarrow$ (14b).

(14) a. Mary did not eat.
b. Mary did not eat an egg.

Let P and Q be any event predicates, then:

$$\begin{aligned} actual(Neg(\lambda e.\ P(e))) &\Rightarrow \forall e.\ P(e) \to \neg actual(e) \\ &\Rightarrow \forall e.\ P(e) \wedge Q(e) \to \neg actual(e) \\ &\Rightarrow actual(Neg(\lambda e.\ P(e) \wedge Q(e))) \end{aligned} \quad (2)$$

6 Compositional implementation

(15) Mary is not eating.

- The terms are composed by functional application or by set intersection.

$$\begin{aligned} [\![\text{not}]\!] &\equiv \lambda Ve.\ e = Neg(\lambda e'.\ Ve') \\ [\![\text{eat}]\!] &\equiv \lambda e.\ eat(e) \\ [\![\text{Mary}]\!]_{\mathtt{Ag}} &\equiv \lambda e.\ \mathtt{Ag}(e) = Mary \\ closure &\equiv \lambda S.\ \exists e.\ actual(e) \wedge Se \end{aligned}$$

- The meaning of (15) is not correctly encoded in (16): this formula entails, by axiom (10), that no eating event is actual.

(16) $\exists e.\ actual(e) \wedge \mathtt{Ag}(e) = Mary \wedge e = Neg(\lambda e'.\ eat(e'))$

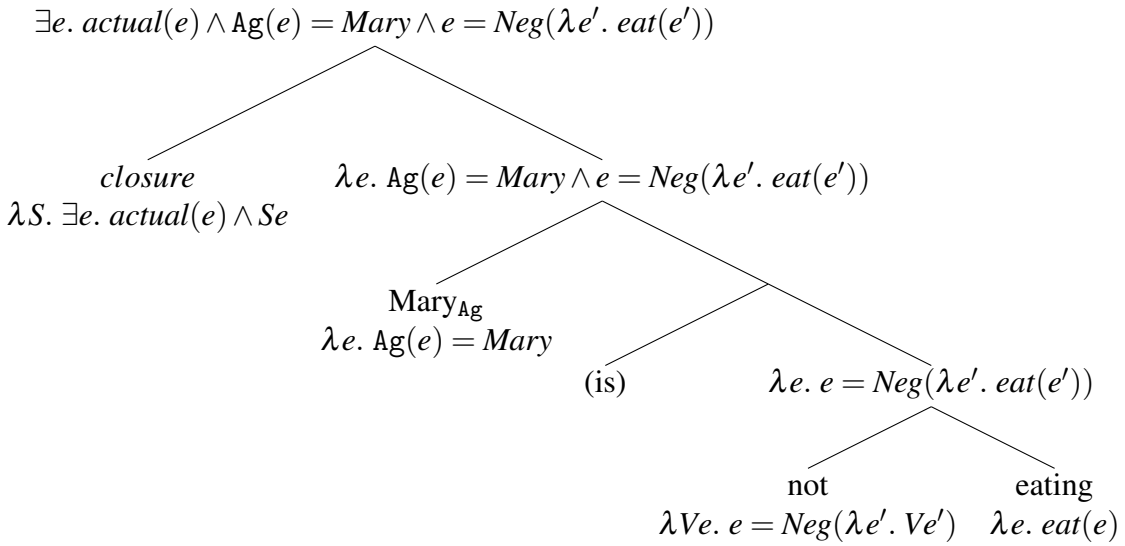

Figure 2: Not a correct derivation of "Mary is not eating".

- The correct translation is (17):

(17) $\exists e.\ actual(e) \wedge e = Neg(\lambda e'.\ eat(e') \wedge \mathtt{Ag}(e') = Mary)$

- To give VP negation semantic scope outside of its syntactic scope, we use an additional θ parameter, similar to the one of the distributivity particles, constrained to the θ-role of the subject.

(18) $[\![\text{not}]\!]_\theta \equiv \lambda Ve.\ e = Neg(\lambda e'.\ \theta(e) = \theta(e') \wedge Ve')$

- We will assume one additional axiom:

(19) $\forall \theta, P, x.\ \theta(Neg(P)) = x \leftrightarrow (\forall e.\ Pe \rightarrow \theta(e) = x))$

- Now, we get for (15) the following interpretation:

(20) $\exists e.\ actual(e) \wedge \mathtt{Ag}(e) = Mary \wedge e = Neg(\lambda e'.\ \mathtt{Ag}(e) = \mathtt{Ag}(e') \wedge eat(e'))$
(equivalent to (17) because of axiom (19))

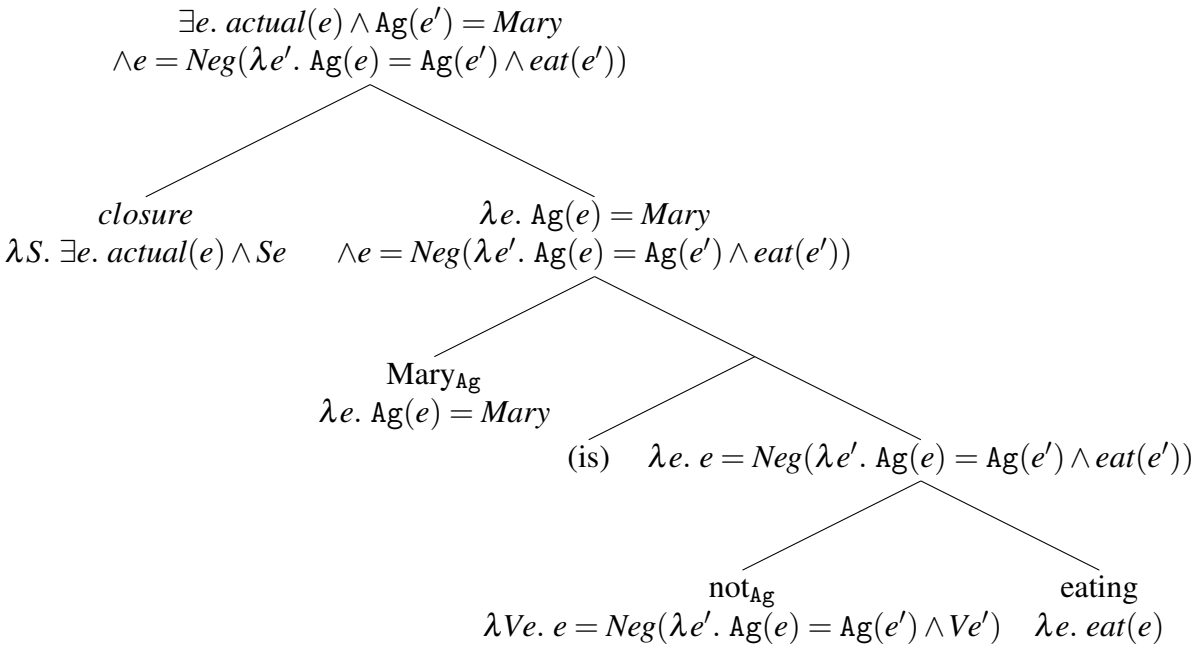

Figure 3: A correct derivation of "Mary is not eating".

- Axiom (19) is not neutral about the interpretation of what "negative" events and thematic roles are. An alternative is to suppose for each thematic role θ the existence of a thematic role $\overline{\theta}$ such that if θ is the role of Mary is *Mary VP* then $\overline{\theta}$ is her role in *Mary not VP*. When can then replace axiom (19) with axiom (21a), use term (21b) for the negation and get formula (21c) for the interpretation of (15).

(21) a. $\forall \theta, P, x.\ \overline{\theta}(Neg(P)) = x \leftrightarrow (\forall e.\ Pe \rightarrow \theta(e) = x))$
b. $[\![\text{not}]\!]_\theta \equiv \lambda Ve.\ e = Neg(\lambda e'.\ \overline{\theta}(e) = \theta(e') \wedge Ve')$
c. $[\![(15)]\!] \equiv \exists e.\ actual(e) \wedge \overline{\mathtt{Ag}}(e) = Mary \wedge e = Neg(\lambda e'.\ \overline{\mathtt{Ag}(e)} = \mathtt{Ag}(e') \wedge eat(e'))$

7 Back to distributivity

- Adverbial *each* (same as in Champollion 2016b):

$$[\![\text{each}]\!]^{\text{adv}}_\theta \equiv \lambda Ve.\ (e \in {}^*\lambda e'.\ atom(\theta(e')) \wedge Ve')$$

(22) John and Mary each did not build a raft.

(23) $closure([\![\text{John and Mary}]\!]_{\mathtt{Ag}} \cap ([\![\text{each}]\!]_{\mathtt{Ag}}([\![\text{not}]\!]_{\mathtt{Ag}}([\![\text{build}]\!] \cap [\![\text{a raft}]\!]_{\mathtt{Th}}))))$

$$
\begin{array}{ll}
\zeta_1 \equiv [\![\text{build}]\!] \cap [\![\text{a raft}]\!]_{\texttt{Th}} & \equiv \lambda e.\ \mathit{build}(e) \wedge \mathit{raft}(\texttt{Th}(e)) \\
\zeta_2 \equiv [\![\text{not}]\!]_{\texttt{Ag}}(\zeta_1) & \equiv \lambda e.\ e = \mathit{Neg}(\lambda e'.\ \texttt{Ag}(e) = \texttt{Ag}(e') \wedge \mathit{build}(e') \wedge \mathit{raft}(\texttt{Th}(e'))) \\
\zeta_3 \equiv [\![\text{each}]\!]_{\texttt{Ag}}(\zeta_2) & \equiv \lambda e.\ (e \in {}^*\lambda e'.\ \mathit{atom}(\texttt{Ag}(e')) \\
 & \wedge e' = \mathit{Neg}(\lambda e''.\ \texttt{Ag}(e') = \texttt{Ag}(e'') \wedge \mathit{build}(e'') \wedge \mathit{raft}(\texttt{Th}(e'))) \\
\zeta_4 \equiv [\![\text{John and Mary}]\!]_{\texttt{Ag}} \cap \zeta_3 & \equiv \lambda e.\ \texttt{Ag}(e) = \mathit{John} \oplus \mathit{Mary} \wedge (e \in {}^*\lambda e'.\ \mathit{atom}(\texttt{Ag}(e')) \\
 & \wedge e' = \mathit{Neg}(\lambda e''.\ \texttt{Ag}(e') = \texttt{Ag}(e'') \wedge \mathit{build}(e'') \wedge \mathit{raft}(\texttt{Th}(e'))) \\
\zeta_5 \equiv \mathit{closure}(\zeta_4) & \equiv \exists e.\ \mathit{actual}(e) \wedge \texttt{Ag}(e) = \mathit{John} \oplus \mathit{Mary} \wedge (e \in {}^*\lambda e'.\ \mathit{atom}(\texttt{Ag}(e')) \\
 & \wedge e' = \mathit{Neg}(\lambda e''.\ \texttt{Ag}(e') = \texttt{Ag}(e'') \wedge \mathit{build}(e'') \wedge \mathit{raft}(\texttt{Th}(e')))
\end{array}
$$

8 Conclusion

- We have defined a notion of negative events that reflects the logic of negation in natural language.
- This logic does not rely on linking an event with "its negative counterpart" (as might be the intuition) but on linking a set of events to a *precluder*.
- These negative events mesh well with mereological approaches of event semantics, which allows us to treat negation in distributive sentence intuitively and stick to the traditional views of verbs as sets of events.

Future work:

- Use this notion of negative events to handle perception reports (*I saw not* ϕ), causal statement (ψ *because not* ϕ), temporal modification (*for two hours, not* ϕ).
- Explore in more details the logic of *Neg*.
- Alternatives to the θ parameter added to VP negation: VP internal subject hypothesis (Koopman & Sportiche 1991), continuation (Barker & Shan 2014).

References

Barker, Chris & Chung-chieh Shan. 2014. *Continuations and natural language*. Oxford, UK: Oxford University Press.

Champollion, Lucas. 2015. The interaction of compositional semantics and event semantics. *Linguistics and Philosophy* 38(1). 31–66. http://dx.doi.org/10.1007/s10988-014-9162-8.

Champollion, Lucas. 2016a. Covert distributivity in algebraic event semantics. *Semantics and Pragmatics* 9(15). 1–65. http://dx.doi.org/10.3765/sp.9.15.

Champollion, Lucas. 2016b. Overt distributivity in algebraic event semantics. *Semantics and Pragmatics* 9(16). 1–65. http://dx.doi.org/10.3765/sp.9.16.

Davidson, Donald. 1967. The logical form of action sentences. In Nicholas Rescher (ed.), *The logic of decision and action*, 81–95. Pittsburgh, PA: University of Pittsburgh Press. http://dx.doi.org/10.1093/0199246270.003.0006.

de Groote, Philippe & Yoad Winter. 2015. A type-logical account of quantification in event semantics. In Tsuyoshi Murata, Koji Mineshima & Daisuke Bekki (eds.), *New frontiers in artificial intelligence*, 53–65. Berlin, Germany: Springer. http://dx.doi.org/10.1007/978-3-662-48119-6_5.

Higginbotham, James. 1983. The logic of perceptual reports: An extensional alternative to situation semantics. *The Journal of Philosophy* 80(2). 100–127. http://dx.doi.org/10.2307/2026237.

Higginbotham, James. 2000. On events in linguistic semantics. In James Higginbotham, Fabio Pianesi & Achille C. Varzi (eds.), *Speaking of events*, 18–52. Oxford, UK: Oxford University Press. http://dx.doi.org/10.1093/acprof:oso/9780199239313.003.0002.

Koopman, Hilda & Dominique Sportiche. 1991. The position of subjects. *Lingua* 85(2-3). 211–258. http://dx.doi.org/10.1016/0024-3841(91)90022-w.

Parsons, Terence. 1990. *Events in the semantics of English*. Cambridge, MA: MIT Press.

Schwarzschild, Roger. 2014. Distributivity, negation and quantification in event semantics: Recent work by L. Champollion. Ms. Massachusetts Institute of Technology. http://web.mit.edu/schild/www/papers/public_html/champ.pdf.

Winter, Yoad & Joost Zwarts. 2011. Event semantics and Abstract Categorial Grammar. In Makoto Kanazawa, Marcus Kracht & Hiroyuki Seki (eds.), *Mathematics of Language 12*, vol. 6878 (Lecture Notes in Computer Science), 174–191. Berlin / Heidelberg: Springer. http://dx.doi.org/10.1007/978-3-642-23211-4_11.